Distributed QoS Control

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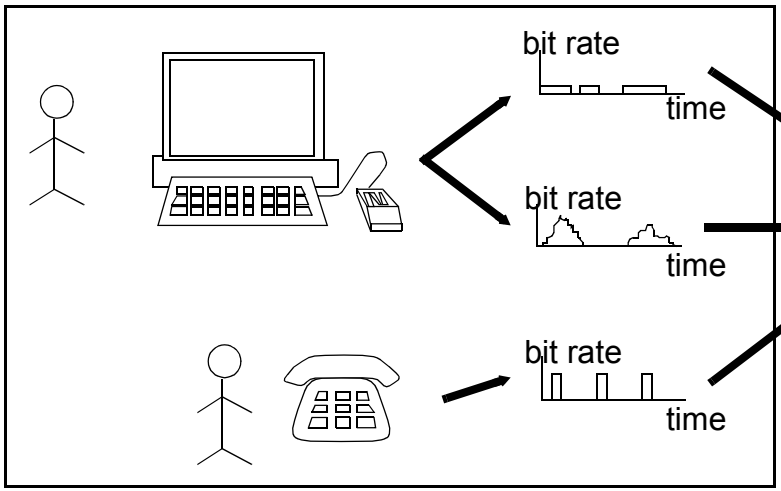
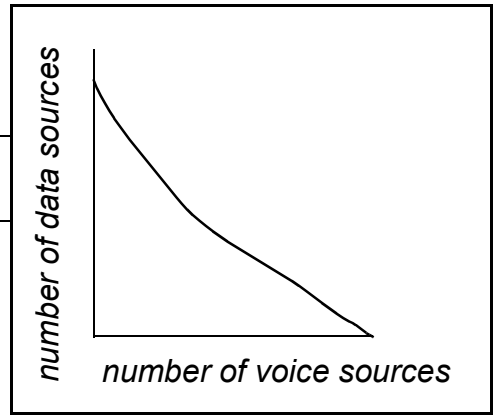
New Ideas

- *Build connections between characterizations of traffic flows, QoS requests, and network resource availability*
- *Negotiations between network and user agents regarding QoS*
- *Minimize information exchange using price & demand*

Impact

- *Reservation of network resources for each traffic flow or aggregates of flows in integrated service architectures*
- *Priority marking of packets in differentiated service architectures*
- *Automate resource management and QoS management tasks*





User

Traffic Characterization

Quality of Service (QoS)

Network

Scheduling / CAC / Policing

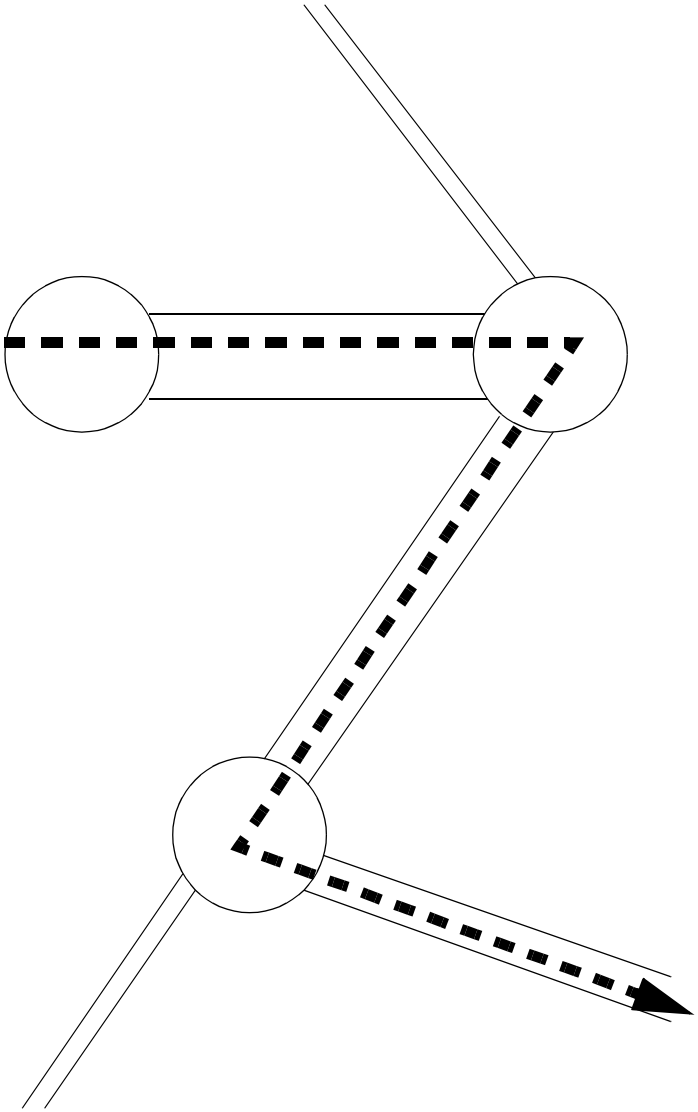
Network Capacity Characterization

Contract

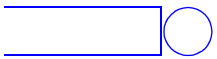
Pricing

Integrated Services

Internet - “RSVP”
ATM - virtual circuits

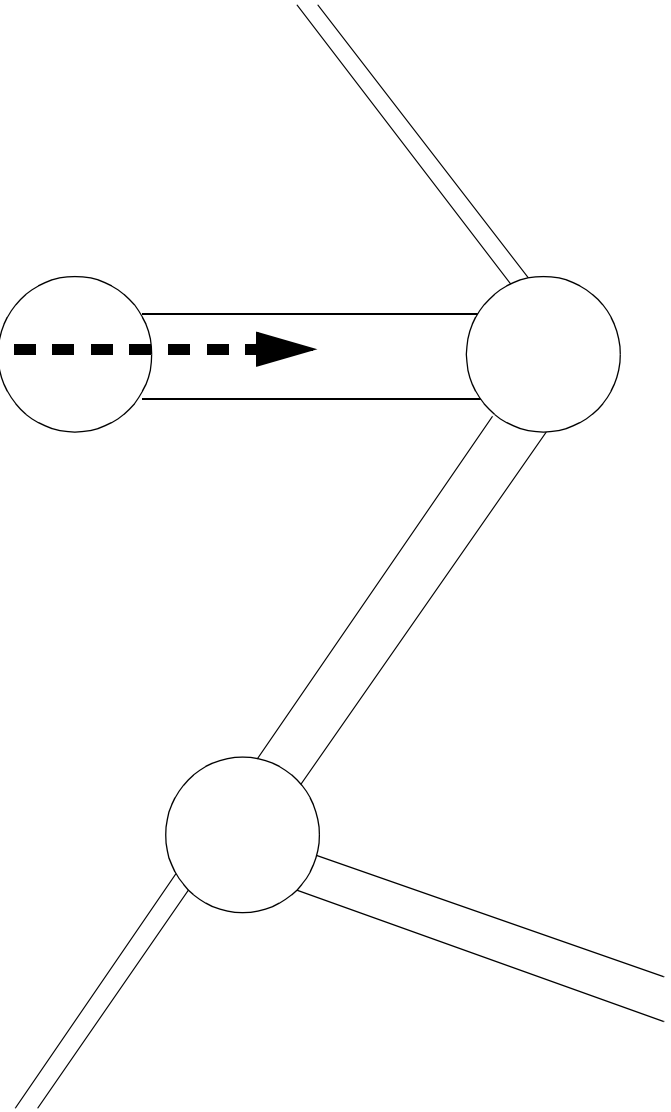


reserve buffer and bandwidth along route

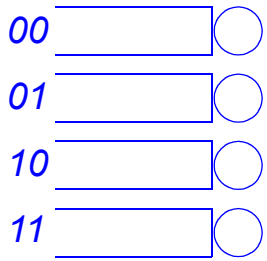


Differentiated Services

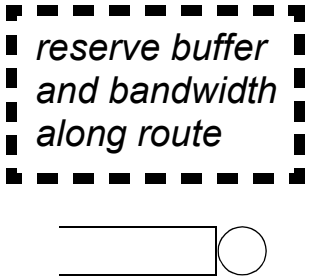
Internet - “diffServ”



label packets with traffic class



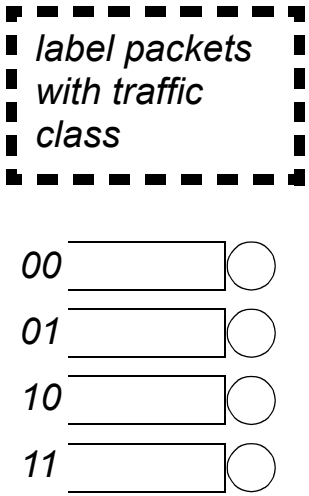
Integrated Services



How much buffer and bandwidth should I reserve ??

Depends on desired QoS and congestion !!

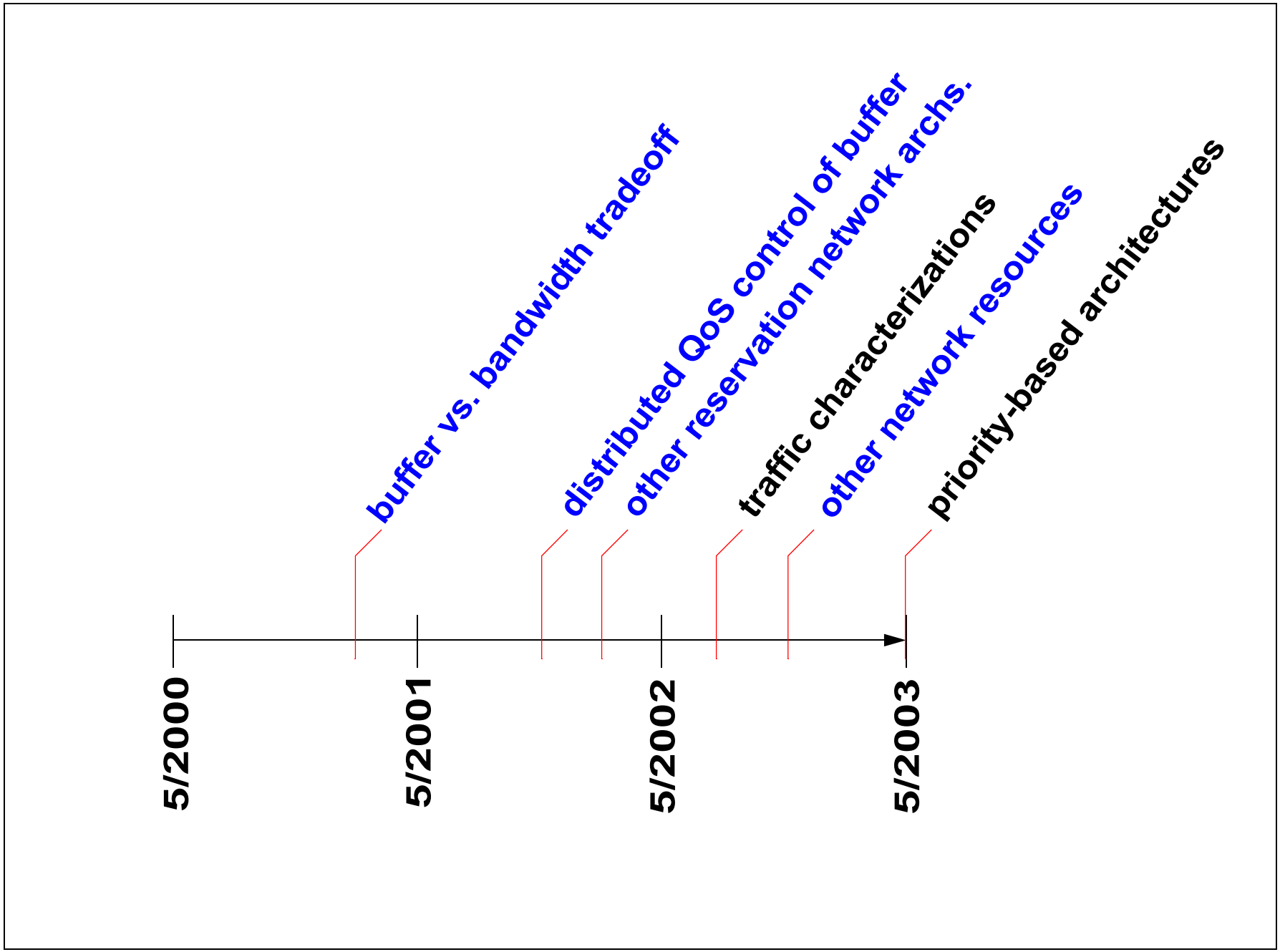
Differentiated Services



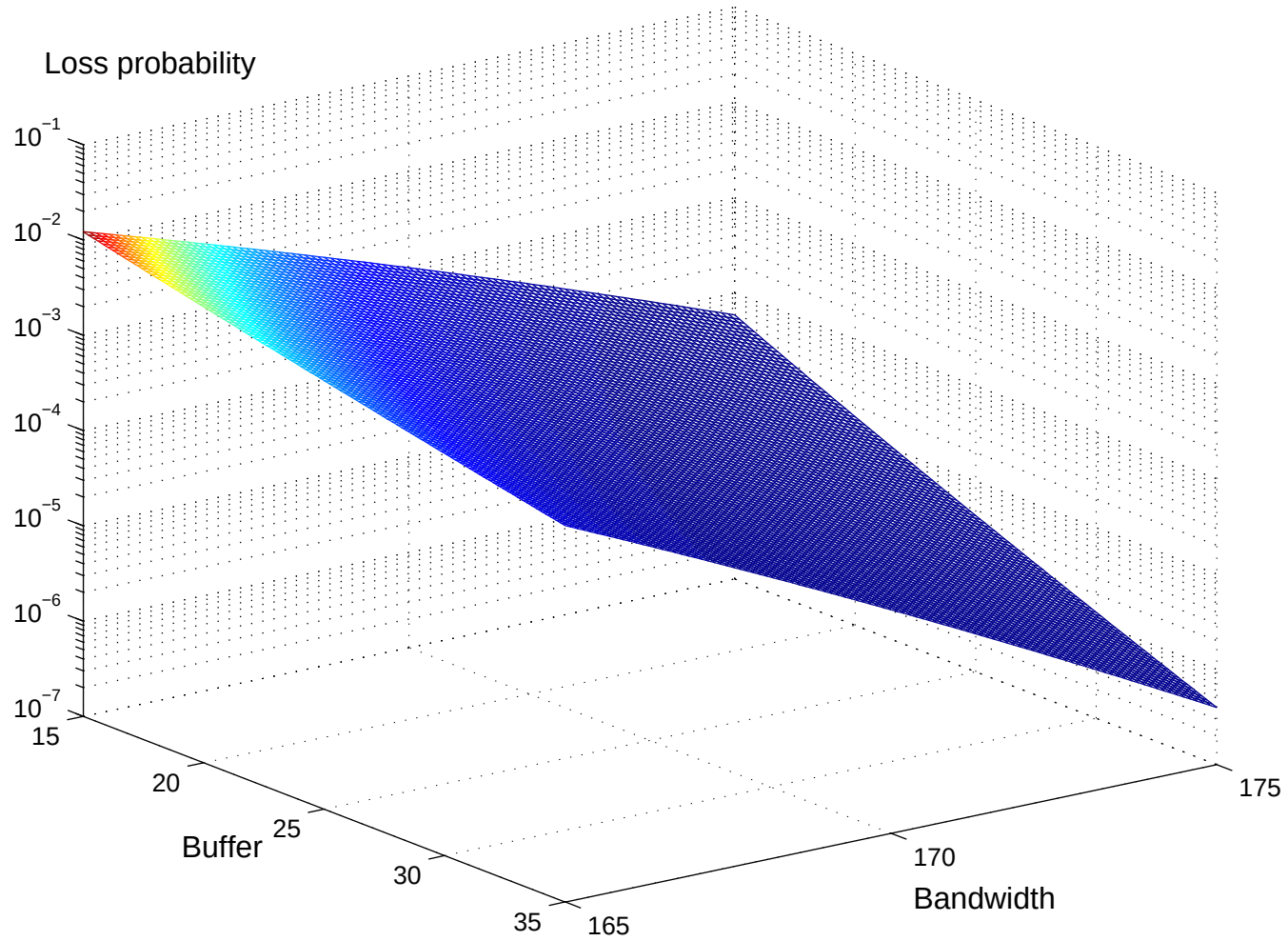
Which traffic class(es) should I use ??

Depends on desired QoS and congestion !!

Timeline

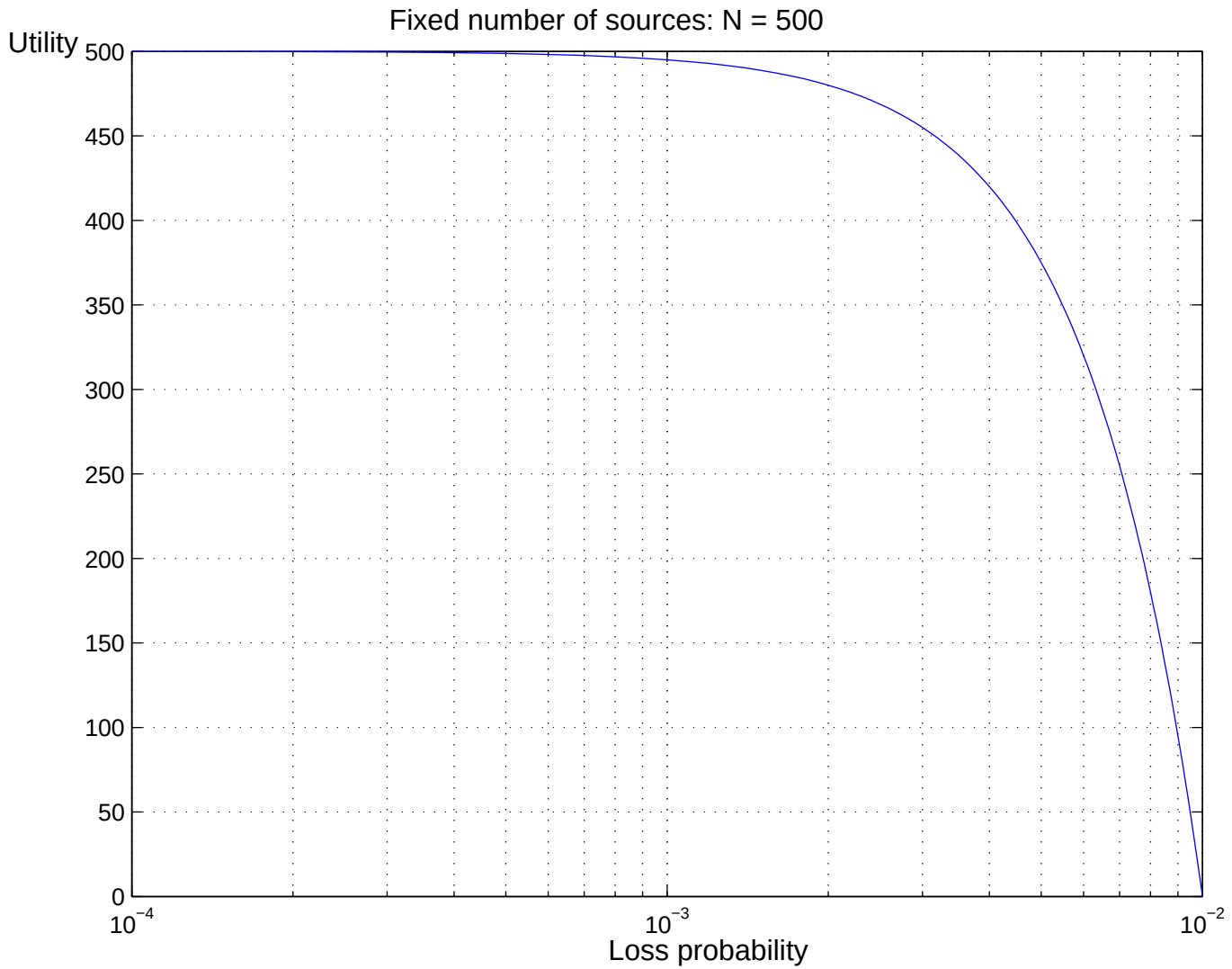

buffer vs. bandwidth tradeoff
distributed QoS control of buffer
other reservation network archs.
traffic characterizations
other network resources
priority-based architectures
5/2000
5/2001
5/2002
5/2003

Loss surface for a class of on/off sources



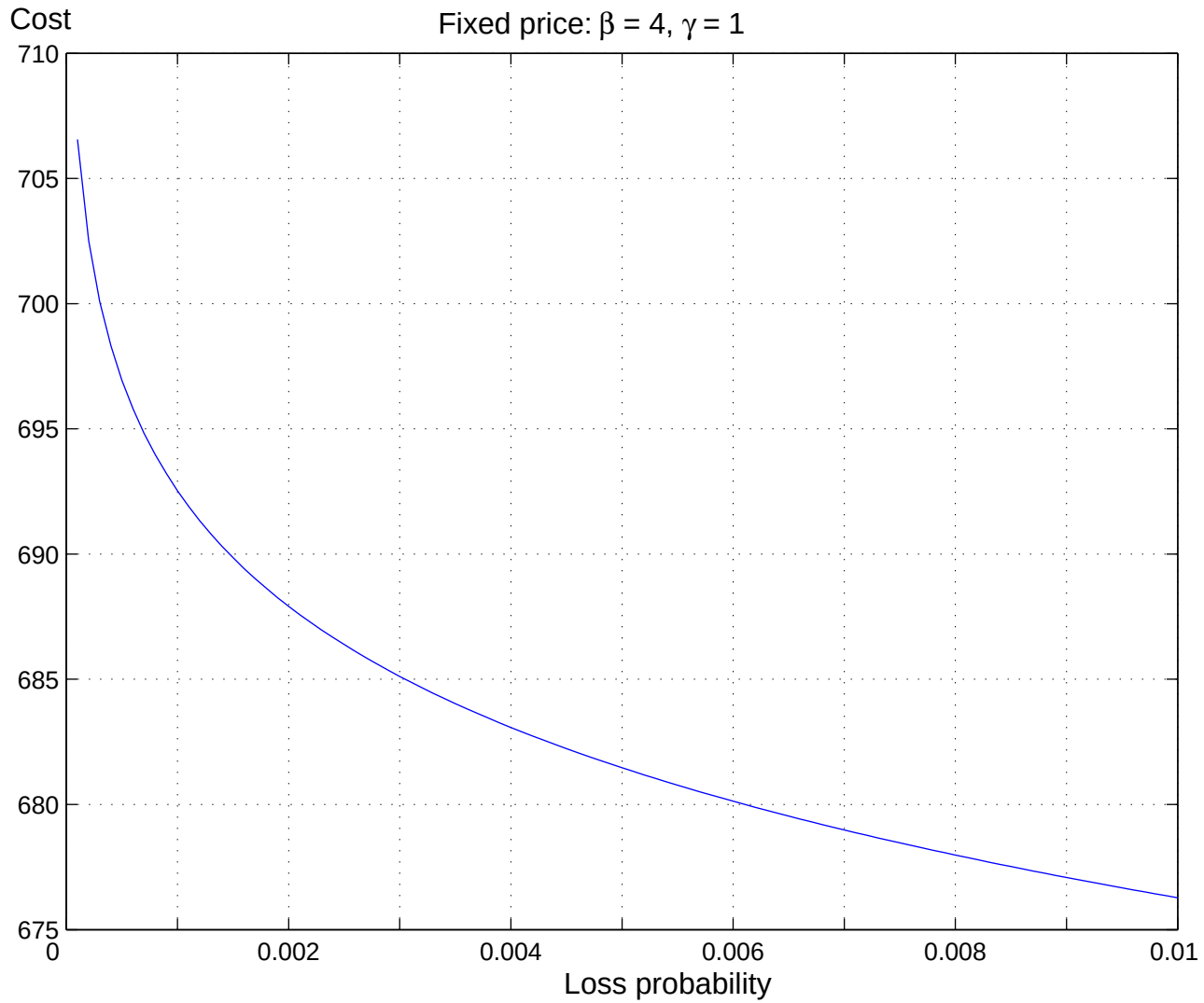
500 on/off sources with P(on)=0.3036

Utility function for a class of on/off sources



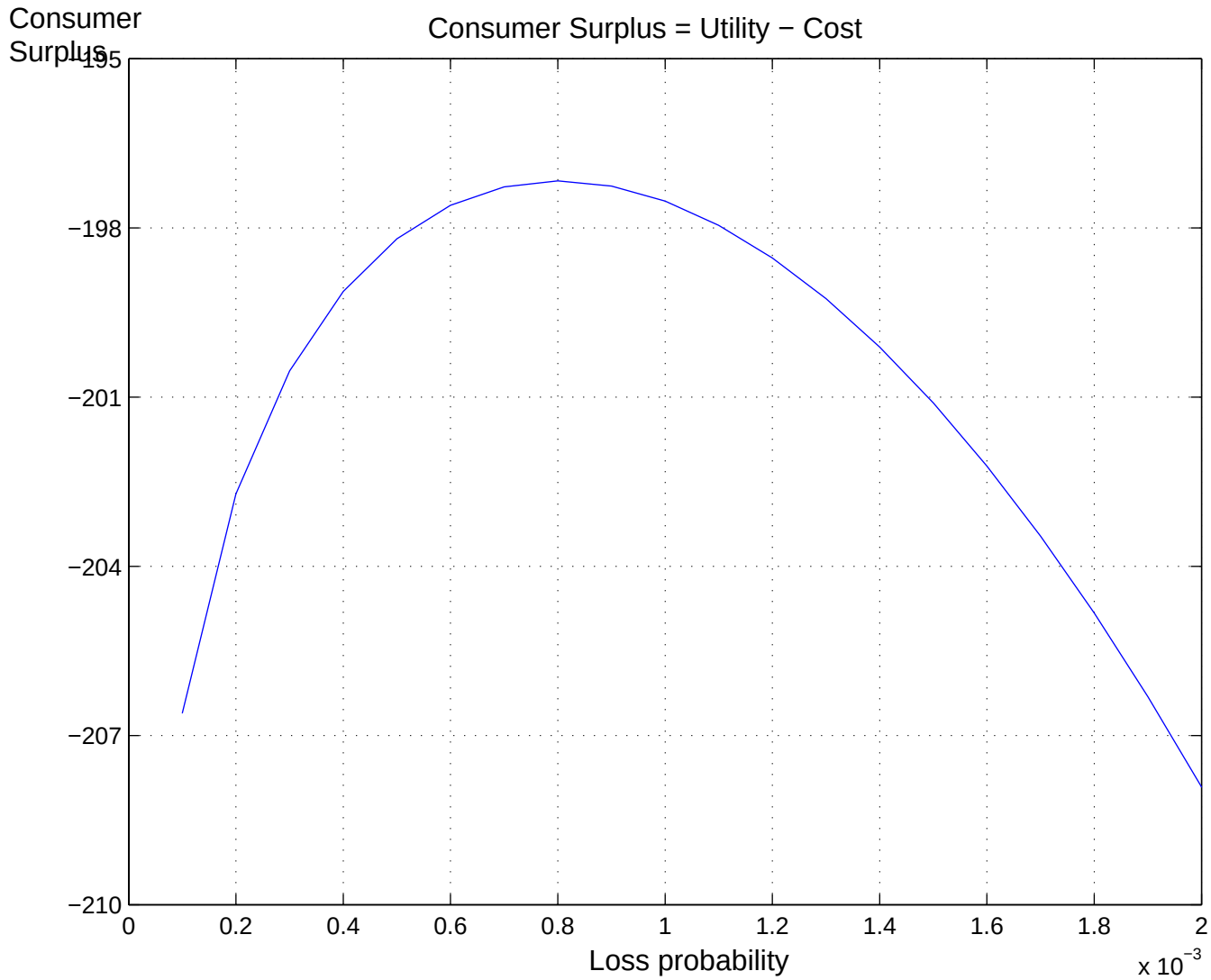
500 on/off sources with P(on)=0.3036

Cost for a class of on/off sources under fixed prices



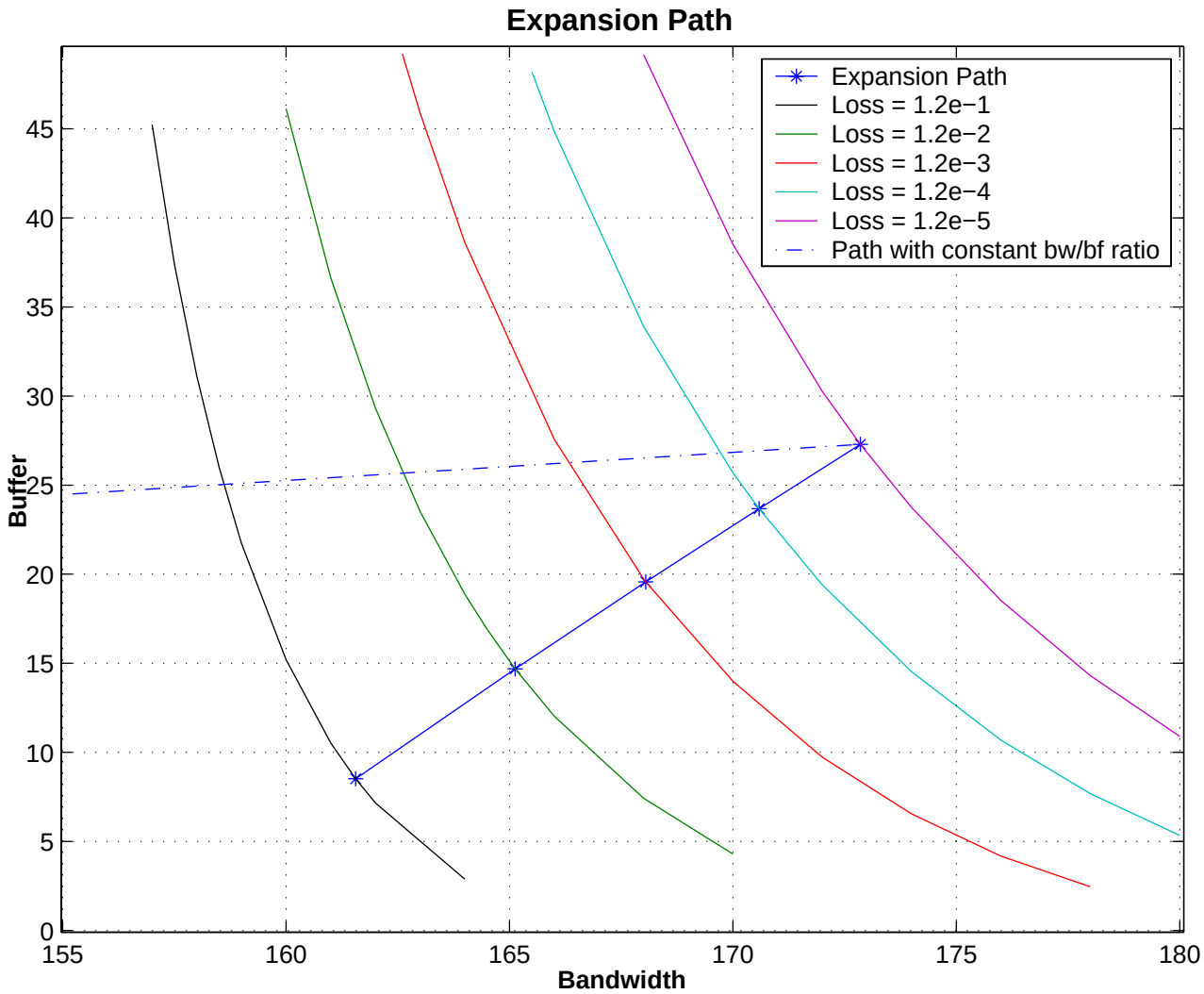
500 on/off sources with P(on)=0.3036

Surplus for a class of on/off sources under fixed prices



500 on/off sources with P(on)=0.3036

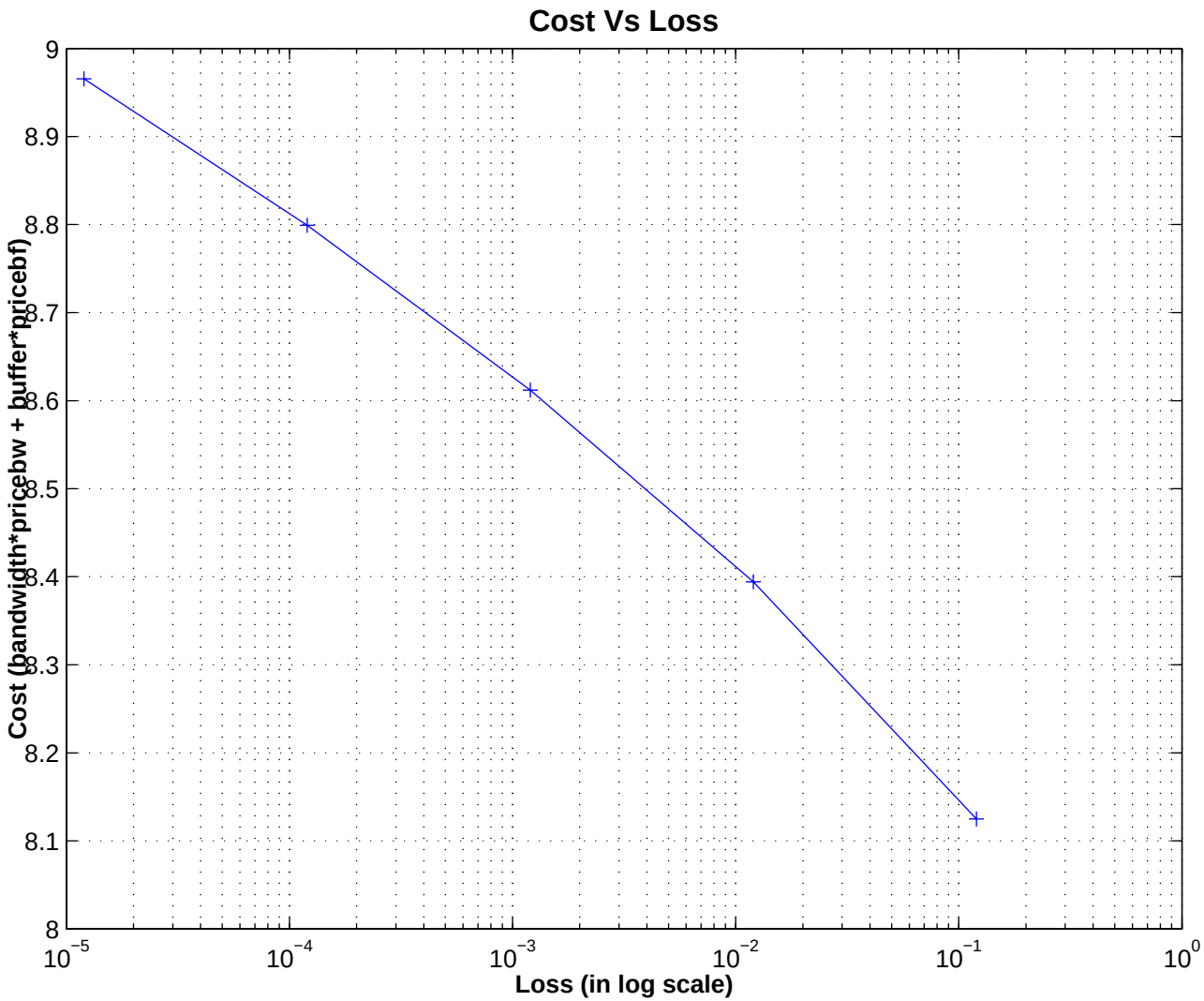
Optimal resource allocation under a fixed price ratio



500 on/off sources with P(on)=0.3036 P_{bw} & P_{bf} varied with P_{bw}/P_{bf} held constant

Theorem: dBF/dBW > 0 iff $g_{wf} < \min [(g_w/g_f)g_{ff}, (g_f/g_w)g_{ww}]$

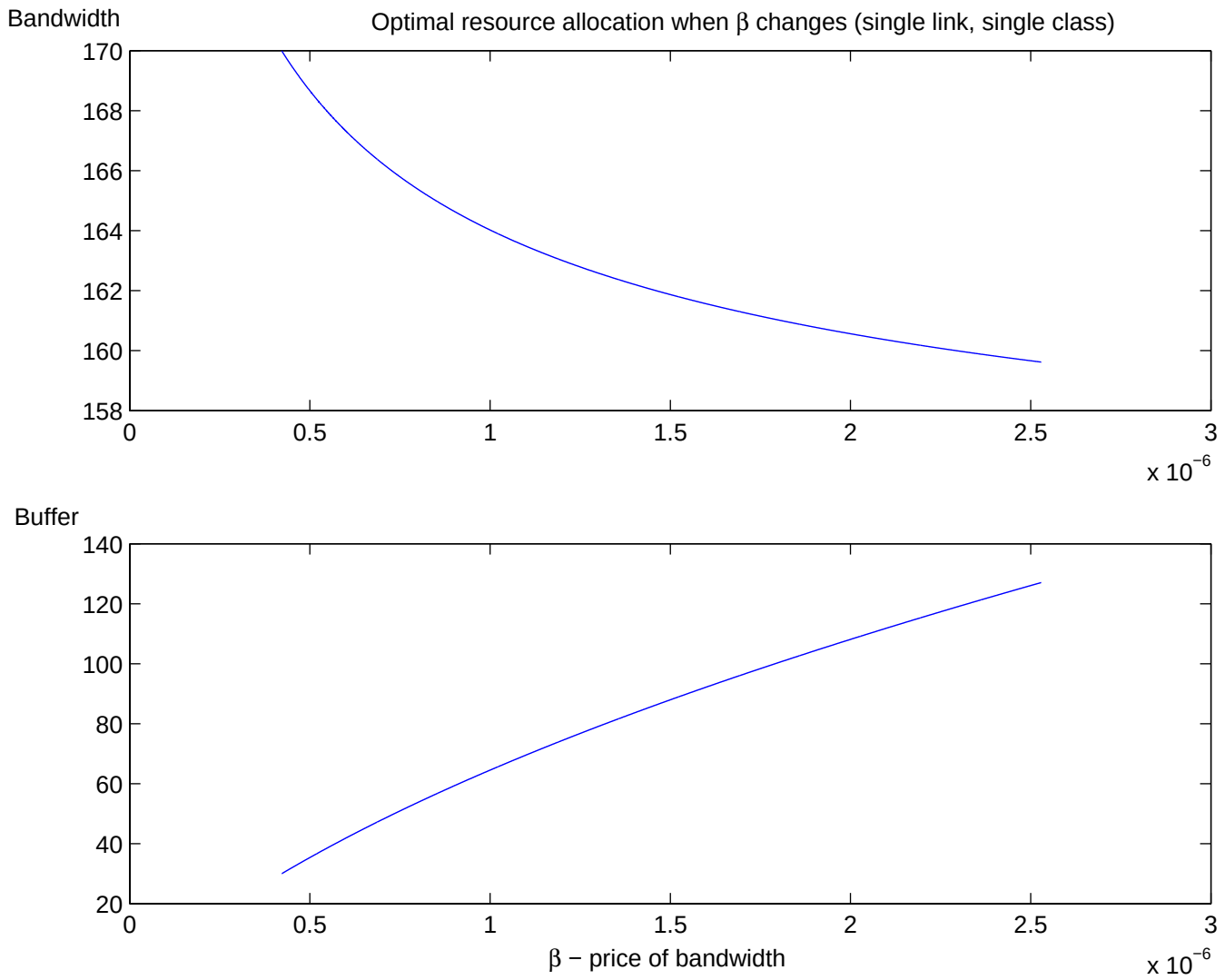
Optimal class loss under a fixed price ratio



500 on/off sources with P(on)=0.3036 P_{bw} & P_{bf} varied with P_{bw}/P_{bf} held constant

Theorem: Minimum cost is a decreasing convex function of loss probability

Optimal resource allocation under increasing prices on bandwidth

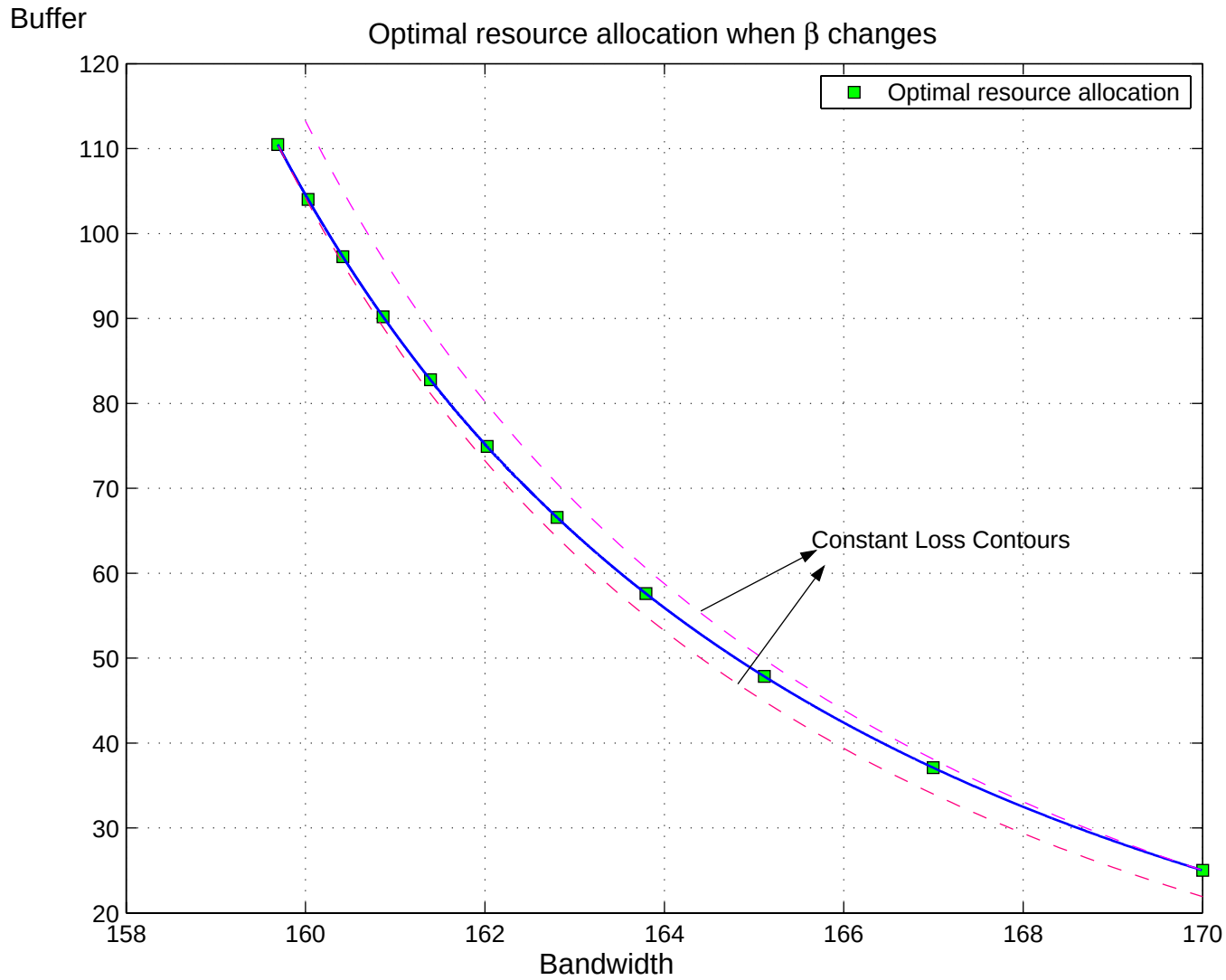


500 on/off sources with P(on)=0.3036

P_{bw} varied with P_{bf} held constant

Theorem: $dBW/dP_{bw} < 0$, $dBF/dP_{bw} > 0$ iff certain conditions on loss function, utility function

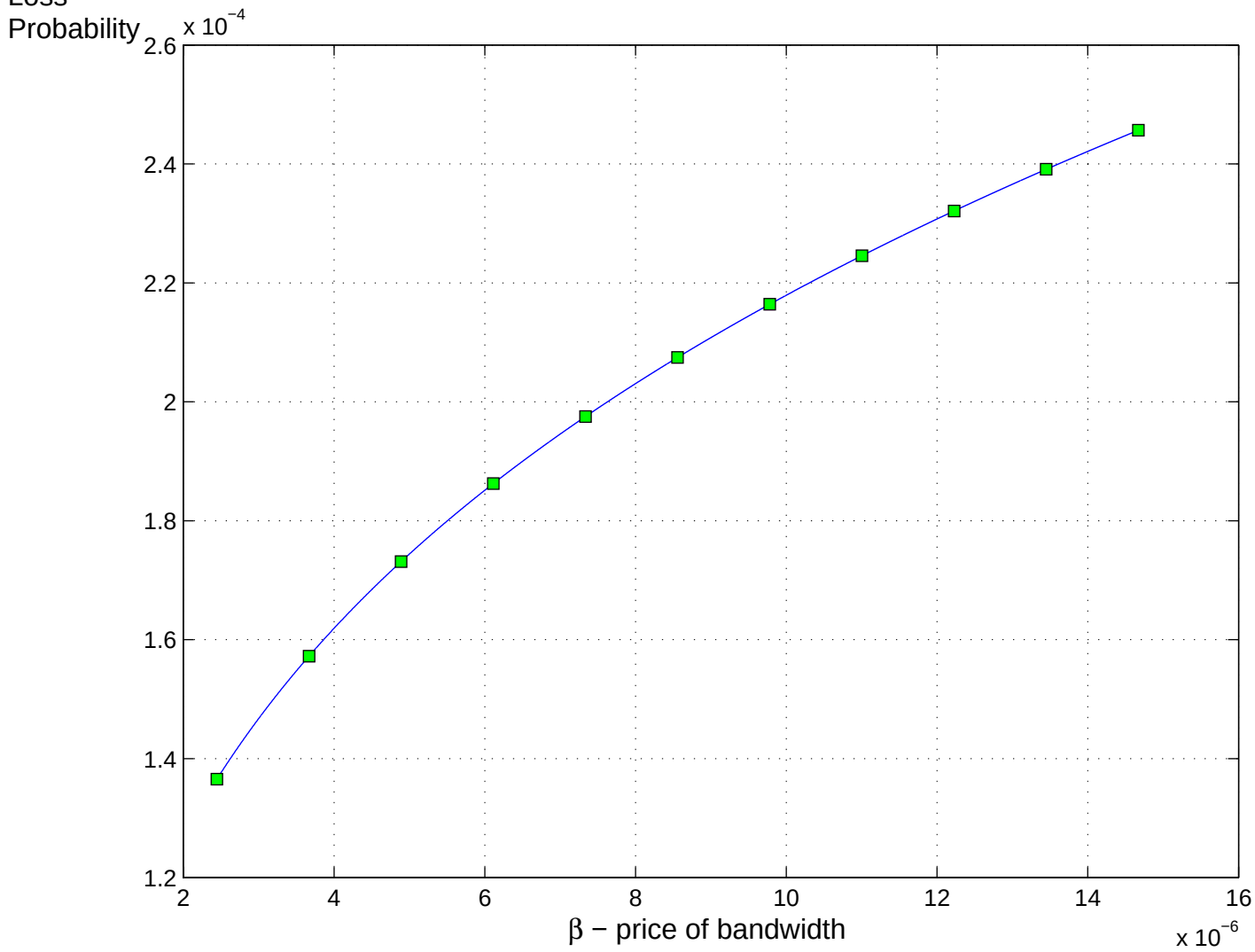
Optimal resource allocation under increasing prices on bandwidth



500 on/off sources with P(on)=0.3036

P_{bw} varied with P_{bf} held constant

Optimal loss under increasing prices on bandwidth

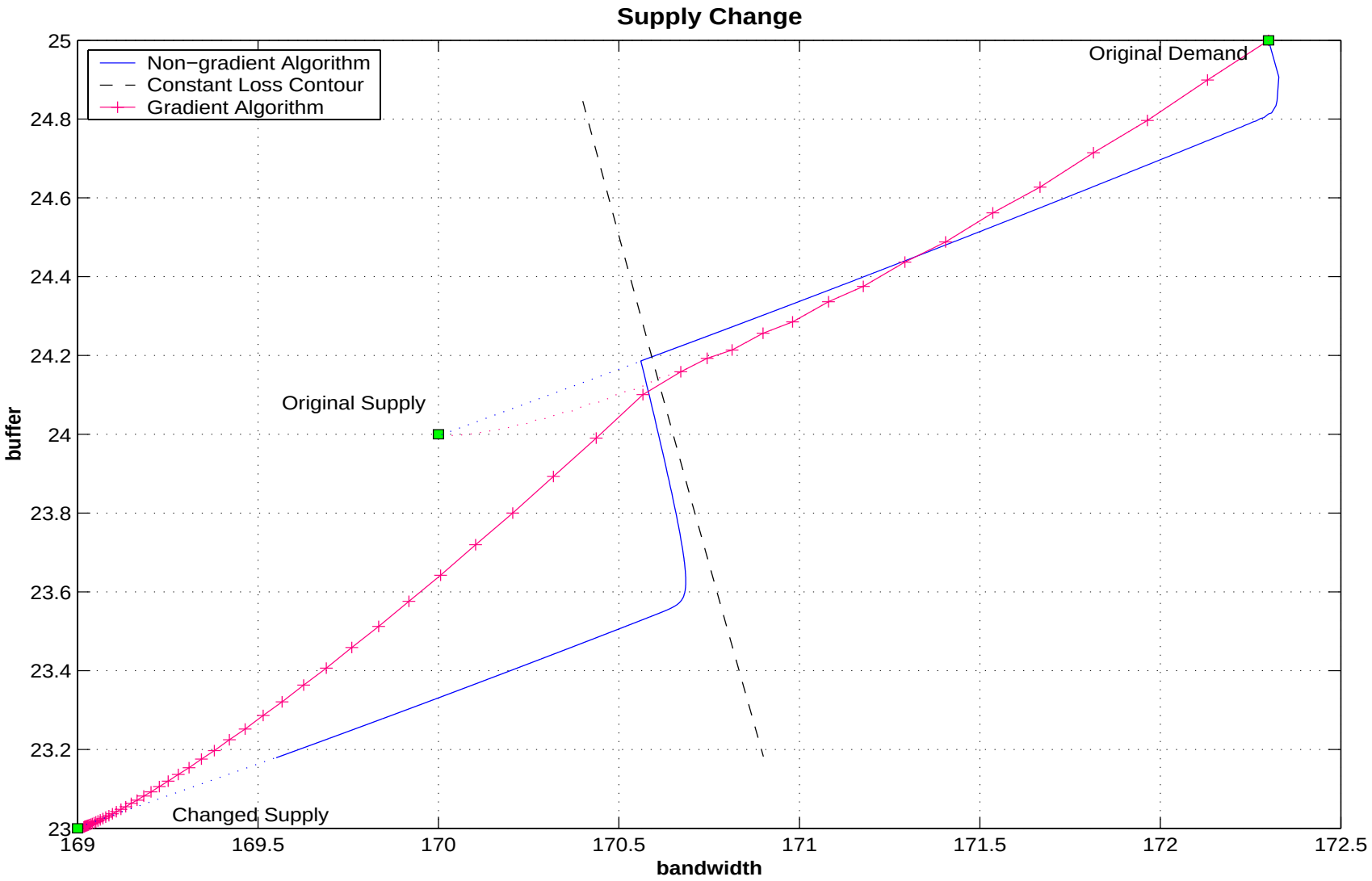


500 on/off sources with P(on)=0.3036

P_{bw} varied with P_{bf} held constant

Theorem: $dL/dP_{bw} > 0$ if $g_{wf} < (g_w/g_f)g_{ff}$

Convergence using pricing

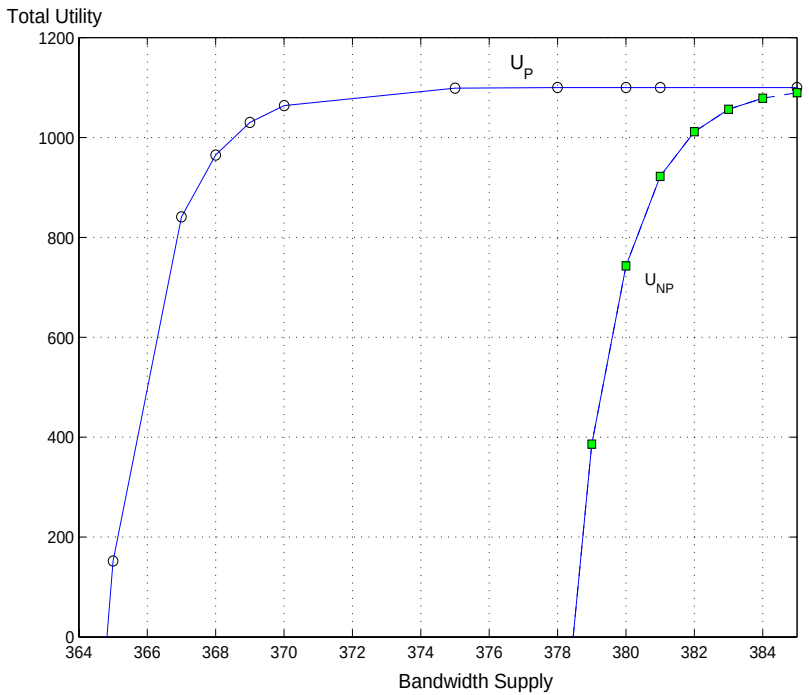


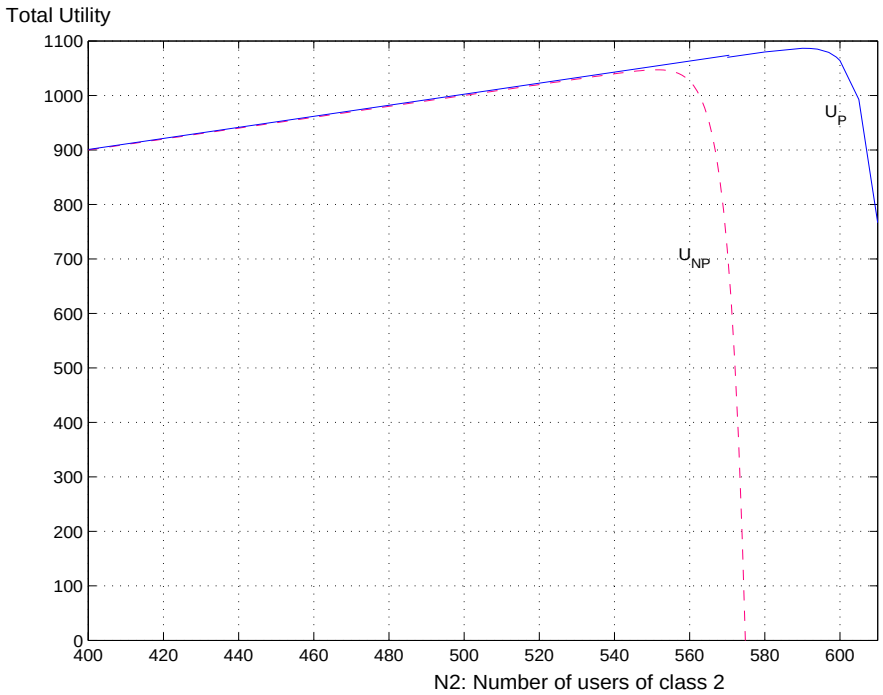
500 on/off sources with P(on)=0.3036

Bandwidth and buffer supplies varied

Convergence of demand to supply, using proportional step & gradient price updates

Utility gain with 2 classes: pricing versus non-pricing





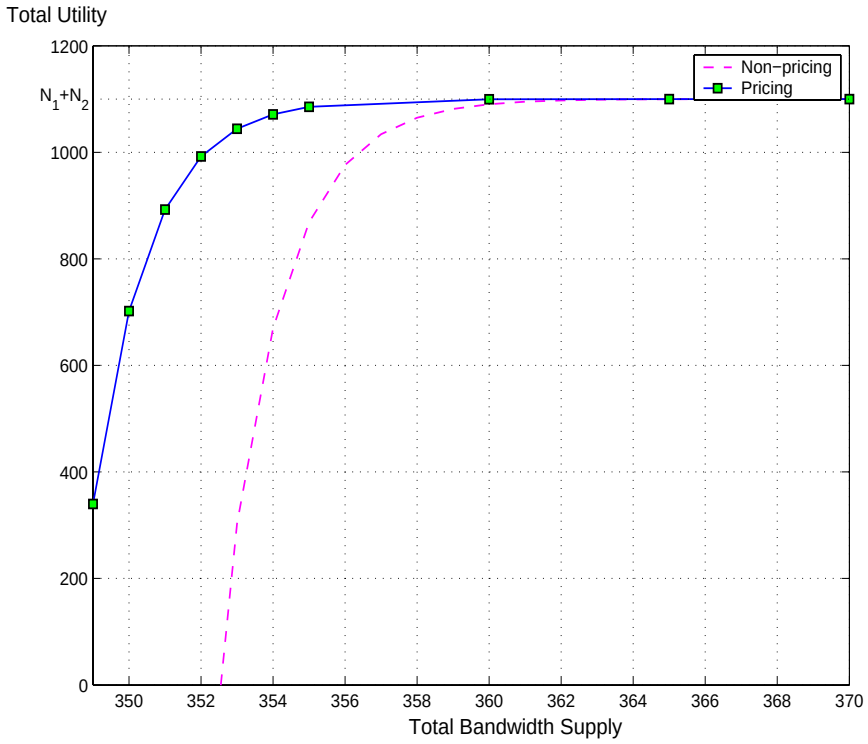
2 classes with 500 on/off sources in each class

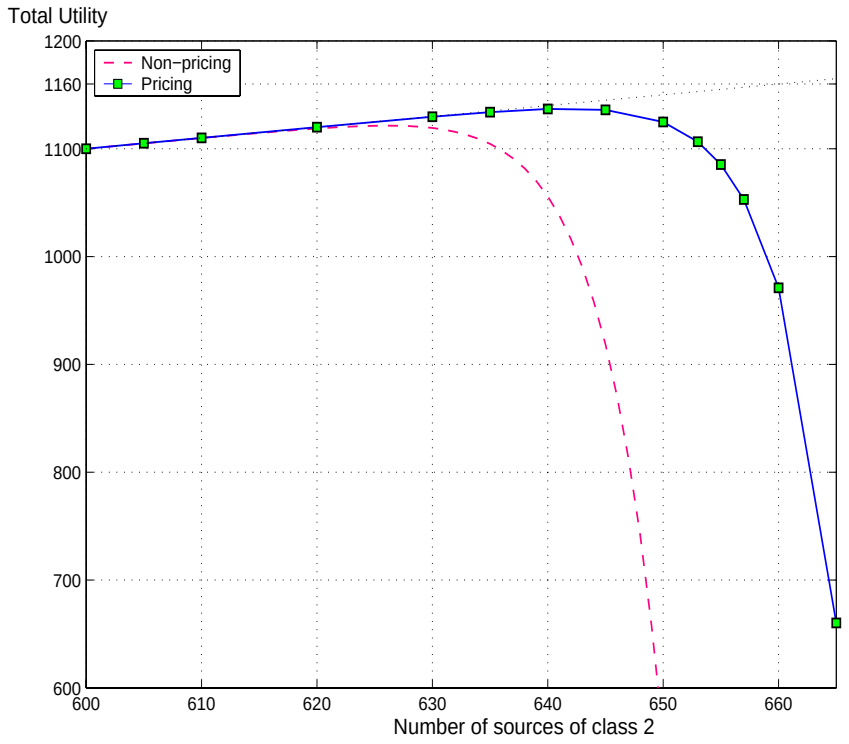
class 1: P(on)=0.3036, max loss = 6.8%
class 2: P(on)=0.3300, max loss = 2.2% (higher mean rate, more demanding)

BW supply varied number of sources in class 2 varied

Non-pricing = allocate BW & BF proportional to number of sources in each class

Utility gain with 2 classes: pricing versus non-pricing



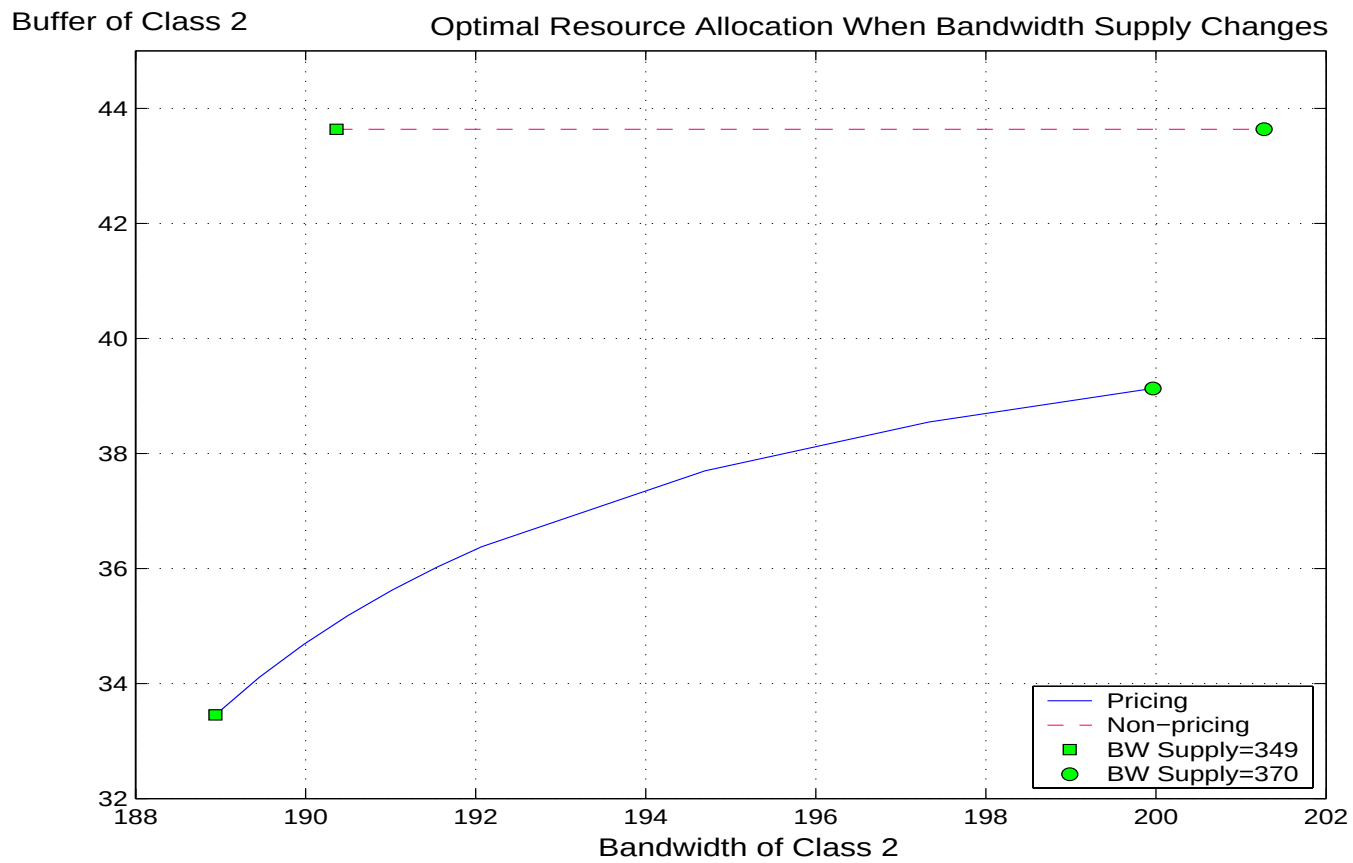


2 classes with 500 on/off sources in each class

class 1: P(on)=0.3036, max loss = 1% (more demanding)
class 2: P(on)=0.3036, max loss = 10%

BW supply varied number of sources in class 2 varied

Non-pricing = allocate BW & BF proportional to total mean rate of each class



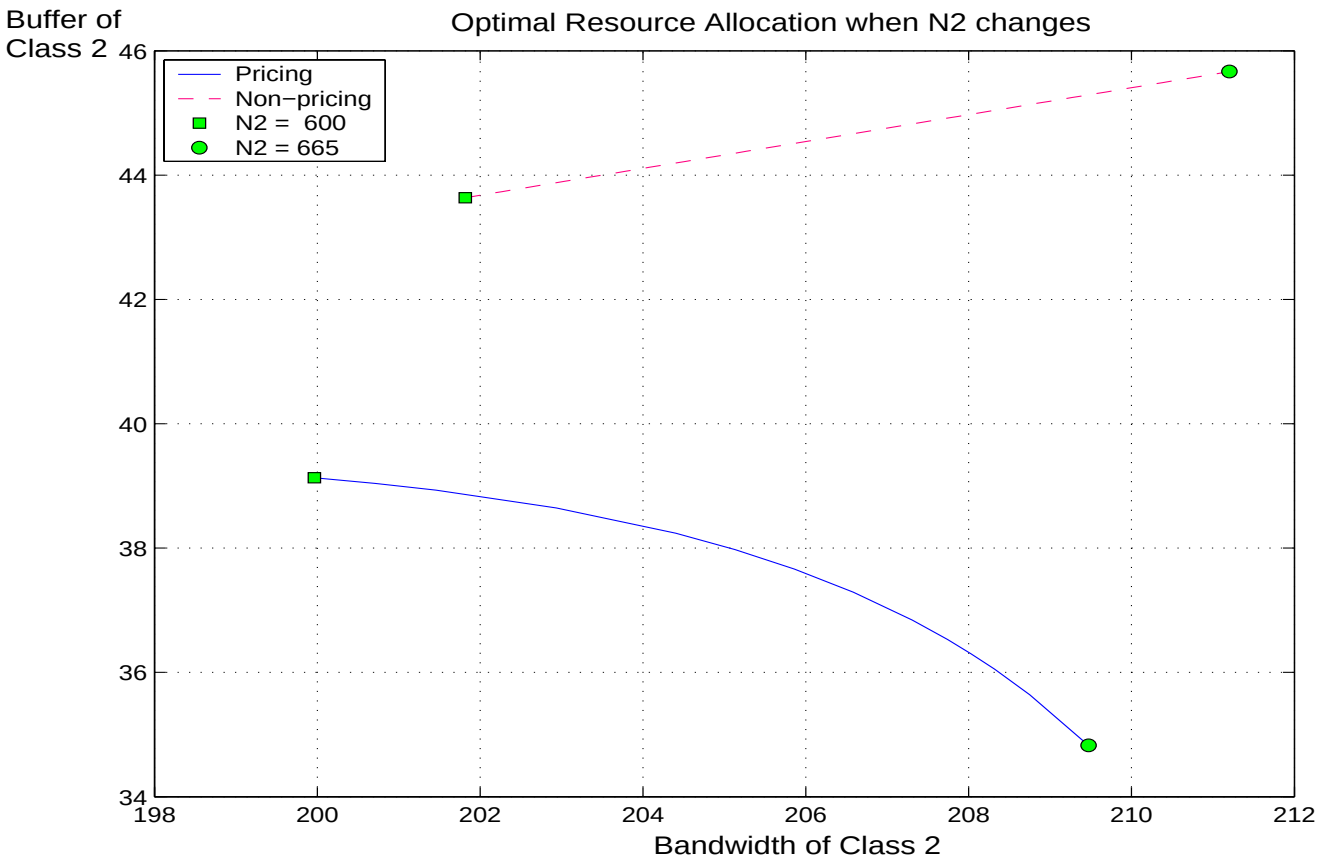
2 classes with 500 on/off sources in each class

class 1: P(on)=0.3036, max loss = 1% (more demanding)
class 2: P(on)=0.3036, max loss = 10%

BW supply varied

Non-pricing = allocate BW & BF proportional to total mean rate of each class

Resource allocation with 2 classes: pricing versus non-pricing



2 classes with 500 on/off sources in class 1 & varying number in class 2

class 1: P(on)=0.3036, max loss = 1% (more demanding)
class 2: P(on)=0.3036, max loss = 10%

number of sources in class 2 varied

Non-pricing = allocate BW & BF proportional to total mean rate of each class

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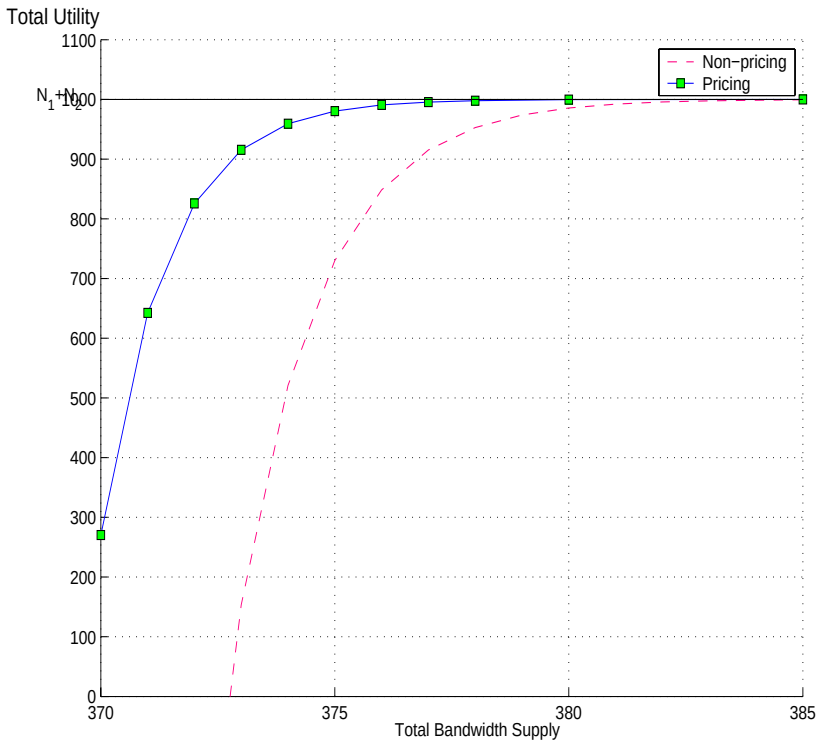
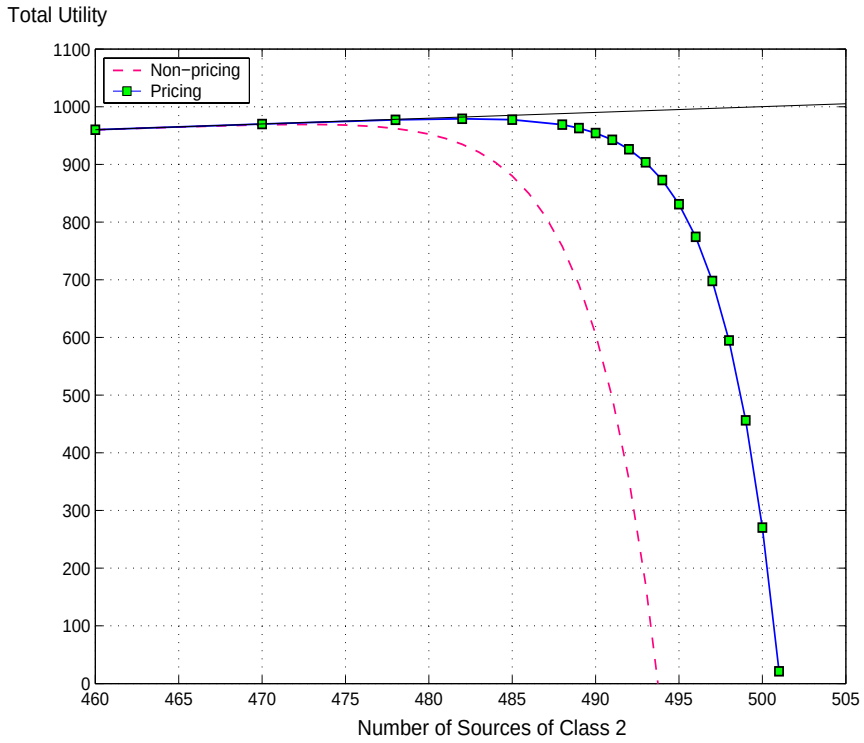
Distributed QoS Control

Utility gain with 2 classes: pricing versus non-pricing





2 classes with 500 on/off sources in each class

class 1: P(on)=0.3036, max loss = 1%
class 2: P(on)=0.4000, max loss = 1% (higher mean rate)

BW supply varied number of sources in class 2 varied

Non-pricing = allocate BW & BF proportional to total mean rate of each class